

**MONTHLY PROGRESS REPORT
MONTANA DOT "PERFORMANCE PREDICTION MODELS"
JANUARY 2004**

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Agency:	Fugro-South, L.P. (Fugro)
MDT Contract No.:	HWY-30604-DT
Contract Period:	June 2001-May 2006
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PROJECT OVERVIEW

The overall objective of this research is to develop a design process and performance/distress prediction models that will enable the Montana Department of Transportation to use mechanistic-empirical principles for flexible pavement design. The project involves a comprehensive performance monitoring and laboratory-testing program and spans a period of five years.

CURRENT MONTH WORK ACTIVITIES AND COMPLETED TASKS

PHASE I

Task 1 – Literature Review

The purpose of the literature review was to summarize existing distress prediction models for load and non-load associated distresses and ride quality, for flexible pavements. The major types of distress considered were: fatigue cracking, permanent deformation, thermal cracking, and ride quality. The primary focus was on the models incorporated in the NCHRP 1-37A Design Guide, but other models were reviewed for their applicability to Montana materials, specifications, and conditions.

Completed: As a result of the literature review, a draft memorandum, summarizing the pavement performance models to be considered within this project, was submitted to the Montana DOT (MDT) in October 2001.

Planned: The results of the calibration and validation of the NCHRP 1-37A Design Guide distress prediction models are still to be released. After these results become available, the team will update the draft memorandum and a final literature review report will be developed.

Task 2 – Review of MT DOT Pavement-Related Data

Under this task, the typical pavement related data specific to the State of Montana was investigated and documented. This included typical pavement structures, materials, soils, climatic conditions, traffic, key modes of distress, maintenance strategies, and pavement data collection procedures normally used on Montana roadways. The two major sources of

information were the Montana DOT data and the LTPP data for experimental sites within and adjacent to Montana.

Completed: A review of the available pavement-related data specific to the State of Montana was completed and included in the Task 3 experimental factorial and sampling/testing plan submitted to the Montana DOT in October 2001.

Ongoing: Because the LTPP database is updated periodically, to ensure the data is accurate and current, Fugro will continue to monitor the LTPP database and update any missing data on the test sections with time. The LTPP database was last updated in June 2003 (Release 16).

Task 3 – Establish the Experimental Factorials

The experimental factorials were established to ensure a statistically sound calibration process based on a database that covers the typical combinations of pavement structure, subgrade soil type, and climate conditions specific for Montana.

Completed: The experimental factorial was completed and submitted to Montana DOT in October 2001. The factorial consists of 93 LTPP test sections of which 40 are in the State of Montana and the remaining 53 in neighboring States and Canada. In addition, 10 supplemental sites have been established and included in the factorial. The 10 non-LTPP sites are: Condon, Deerlodge/Beckhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser, and Hammond.

Task 4 – Develop Work Plan for Monitoring and Testing

Completed: A work plan was developed and provided to Montana DOT in October 2001. The document contains the materials sampling plan, the initial testing plan to document the baseline condition of each test site, the laboratory testing plan to define the material properties and layer thickness at each test site and the performance monitoring plan to document time series data within the 60-month contract period.

Planned: The long-term monitoring plan will be revised after the initial analyses of the data are complete under Tasks 6 and 7.

PHASE II

Task 5 – Presentation of Work Plan to MDT

Completed: The team presented the work plan to Montana DOT team on October 2, 2001.

Task 6 – Implement Work Plan – Data Collection

The monitoring and testing part of the project includes 93 LTPP test sections in Montana or surrounding States and 10 supplemental non-LTPP sites. While the monitoring and testing of the LTPP sites is managed through the LTPP program and all data of interest to the project can be retrieved from the LTPP database, the monitoring and testing of the non-LTPP sites has been managed and coordinated by Montana DOT and Fugro. Therefore, the two categories will be presented separately.

LTPP Sites

There are 93 LTPP sites included in the experimental factorial. Of these, 40 are located in Montana and 53 in neighboring States and Canada. Assessing the availability of testing and monitoring data for the LTPP sites is a tedious and time-consuming process. In addition, with each update of the LTPP database the process has to be repeated. To minimize the time and effort allocated to this task the research team developed a calibration and validation database where all the data extracted from the LTPP database is stored. A set of queries was written that can be used at any time in the future to extract the data needed from the LTPP database to update the information in the calibration/validation database. The database is now complete and populated with LTPP data. A code that runs all queries automatically was used to populate the database and will be provided with the database.

Ongoing: The population of the calibration/validation database with LTPP data is complete, and calibration analyses have been initiated for the LTPP test sections. Along with the calibration exercise, a summary of available testing and monitoring data is made and the areas of the database that lack sufficient data are identified.

Non-LTPP Sites

The 10 non-LTPP sites are: Condon, Deerlodge/Beckhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser, and Hammond.

Completed: A field investigation report has been completed by the project team and includes a summary of the distress surveys, field sampling results (cores, borings, and other geotechnical information), FWD deflections (Round 1 only), and longitudinal profiles from each of the supplemental sites. The field report was submitted to Montana DOT in August 2002.

The first round of deflection tests have been backcalculated and summarized. In addition, the second round of deflection testing has also been backcalculated utilizing the same pavement structure information as the Round 1 data. Comparisons of the laboratory-derived values with FWD derived values were provided in the April and May 2003 monthly reports.

Unbound materials from the 10 sites selected in the experimental factorial were tested at the Fugro-South laboratory in Houston, Texas. Moisture-density curves at modified compactive effort (AASHTO T180) were derived for each of the 17 materials prior to testing. A repeated load resilient modulus test was performed for each material at optimum moisture content and maximum dry density (modified). The results of these tests were presented in the April and May 2003 monthly reports.

Asphalt concrete cores were retrieved from the 10 sites and tested. The tests performed were: indirect tensile (diametral) resilient modulus, indirect tensile strength, low-temperature indirect tensile strength, and low-temperature creep tests. All test results were presented in previous reports (March, April and May 2003) with the exception of the data showing the low temperature indirect strength and strain at failure, which is included in this report.

Cores of cement treated/stabilized bases (CTB/CSB) were tested as well. However, due to specimen size requirements, only two of the seven treated base materials were tested for elastic modulus. Of the remaining five, four have been tested for seismic modulus and one could not be tested. The results of the seismic tests were presented in the August 2003 monthly report. The modulus values obtained were highly variable with values of the coefficient of variation in most cases higher than 40 percent. In the near future, TTI will perform diametral resilient modulus on the same samples to increase our confidence in the results of the seismic testing. Density tests have been performed on five of the seven treated base materials and the results were included in the August 2003 monthly report.

Two of the 10 non-LTPP sites, namely Deerlodge/Beckhill and Condon, contained "pulverized existing HMA and base materials," which were not sampled or tested. The layer moduli assigned to these layers in the calibration analyses are the ones backcalculated from FWD deflections

This Month: The analysis of the low temperature indirect tensile strength tests was completed this month. These tests have been performed on HMA cores earlier in the project. The results are included in Table 6.1.

TABLE 6.1 Low Temperature Indirect Tensile Strength Results

Site	ID	Temp	Load at Failure	Vertical Strain at Failure	Horizontal Strain at Failure
Wolf Point	-20(P25-C5)	-20	-10,232	-0.001030	0.000880
	-20(P25-C13)	-20	-11,454	-0.001105	0.001135
	-10(P25-C4)	-10	-10,743	-0.002225	0.002960
	-10(P25-C9)	-10	-10,689	-0.001740	0.001210
	0(P25-C7)	0	-8,742	-0.005590	0.004935
	0(P25-C14)	0	-7,869	-0.009310	0.006095

Planned: After the results of the calibration exercise on the 10 non-LTPP sites are reviewed, the decision will be made whether more sites are to be included in the testing/monitoring program. Materials are already available for four additional sites (Baum Road, Lothair, Vaughn, and Fort Belknap), of which Lothair and Baum Road have tentatively been selected for inclusion in the testing program.

Task 7 – Data Analyses and Calibration of Performance Prediction Models

The objective of this task is to demonstrate the calibration technique required to develop and maintain the various model calibration coefficients that will be used by the department both now and in the future. As discussed with Montana DOT, four major distress types were considered in the experimental plan that require prediction models and calibration coefficients. These include fatigue cracking (both surface initiated and bottom initiated surface cracks), thermal cracking, rutting or permanent deformation, and ride quality. A second deliverable of Task 7 will be the "calibration and validation database," which will include all the data necessary to validate and calibrate the pavement performance models considered.

Completed: The calibration technique (or the specific steps required to determine calibration coefficients) was demonstrated to Montana DOT utilizing models similar in nature to the NCHRP 1-37A Design Guide models. The project team made a presentation to the department on August 14, 2003, which included a progress report, findings, and an illustration of the calibration exercise for the Silver Spring test section.

The calibration and validation database has been finalized and populated with LTPP data. A set of queries was used to extract the data from the LTPP IMS database to the Montana DOT calibration and validation database. These queries are supported by the current structure of LTPP Data Release 16 (R16). Changes to the structure of the data or the tables in future data releases will require modification/reconstruction, of the current set of queries. For example, the structure of the traffic tables in the data release Version 16 differs from those in the previous versions. The queries written to extract traffic data from earlier releases had to be modified to suit the table structures in the new release. However, such modifications to the LTPP tables are few in number. It is anticipated that further changes will be made to the traffic tables in the future LTPP data releases and hence the traffic queries may need to be updated in the future.

A macro has been developed to run the queries in the required sequence to populate the calibration/validation database. The macro is designed to first clear existing data related to LTPP sites from the calibration/validation database and then to populate the database with the information from the latest LTPP data release. The macro has been tested and the tables have been filled with the information from the latest data release (R16). The documentation and the calibration/validation database will be provided to Montana DOT by mail (CD format).

Ongoing: An initial calibration exercise was performed for the 10 non-LTPP experimental sites. Material test data together with historical traffic and climatic data were used to predict the performance of these sites in terms of fatigue cracking and rutting in the asphalt concrete layer and rutting in the base and subgrade layers. Predicted distress was compared to results of the two distress surveys available for these sites (June 2002 and June 2003) and to the rutting measurements taken in October 2001. The results of this exercise have been included in the July-September 2003 Quarterly Report and are currently under the review of the team.

A calibration analysis, similar to the one performed on the non-LTPP, was started on the LTPP experimental sites. Along with the analysis, the availability of LTPP data is being reviewed. The completeness of the data will be documented and the need for additional information will be assessed. The team is currently in the process of retrieving the data needed for analysis from the Calibration/Validation Database.

This Month: An error in the units used for penetration values was identified in the LTPP database and the Calibration/Validation database: the LTPP data dictionary, data collection form, and data entry form all call for PENETRATION_77_F and PENETRATION_115_F to be reported in millimeters. The QC ranges (5 – 120 and 10 – 250 respectively) imply results should be in 0.1 mm. It is obvious that 250 mm (9.84 in.) far exceeds the maximum measurement of the testing apparatus. It seems likely that values actually entered in the table are a mix of mm and 0.1 mm. A problem report has been submitted identifying the issue. At the earliest, this issue

may be resolved with the next LTPP data upload, which will take place in May 2004 and the corrected data will be available only sometime in late June at the earliest.

Planned: Continue population of the calibration/validation database with information from the 10 non-LTPP sites.

Note that the calibration analyses performed so far do not address specifically the values of the calibration coefficients, but are limited to comparisons of predicted to measured distress using several widely used performance models (not necessarily the NCHRP 1-37A Design Guide models). Upon release of the NCHRP 1-37A Design Guide, the team will replace the current versions of the models with the Design Guide models and then proceed to the actual calibration of model coefficients. In addition, climatic/moisture data will be extracted from the Design Guide environmental database, which includes information for Montana and surrounding regions.

Task 8 – Final Report and Presentation of Results

No activity.

PROBLEMS / RECOMMENDED SOLUTIONS

No problems were encountered during last month and none are anticipated next month.

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below:

- Coordinate with Montana DOT personnel on an as-needed basis.
- Finalize review of calibration exercise for non-LTPP sites and continue analysis of the LTPP sites.
- Continue populating the database with the data from non-LTPP sites.

FINANCIAL STATUS

The Financial Summary I table shows the estimated expenses incurred during the reporting period.

The Financial Summary II table provides the total project expenditures by the Montana and FHWA fiscal years in comparison to the allocated funds for each fiscal year.

The Financial Summary III-A chart illustrates total expenditures from inception of the project June 2000 through December 2003. The Financial Summary III-B chart reflects total project expenditures from January 2004 to the end of the project, May 2006.

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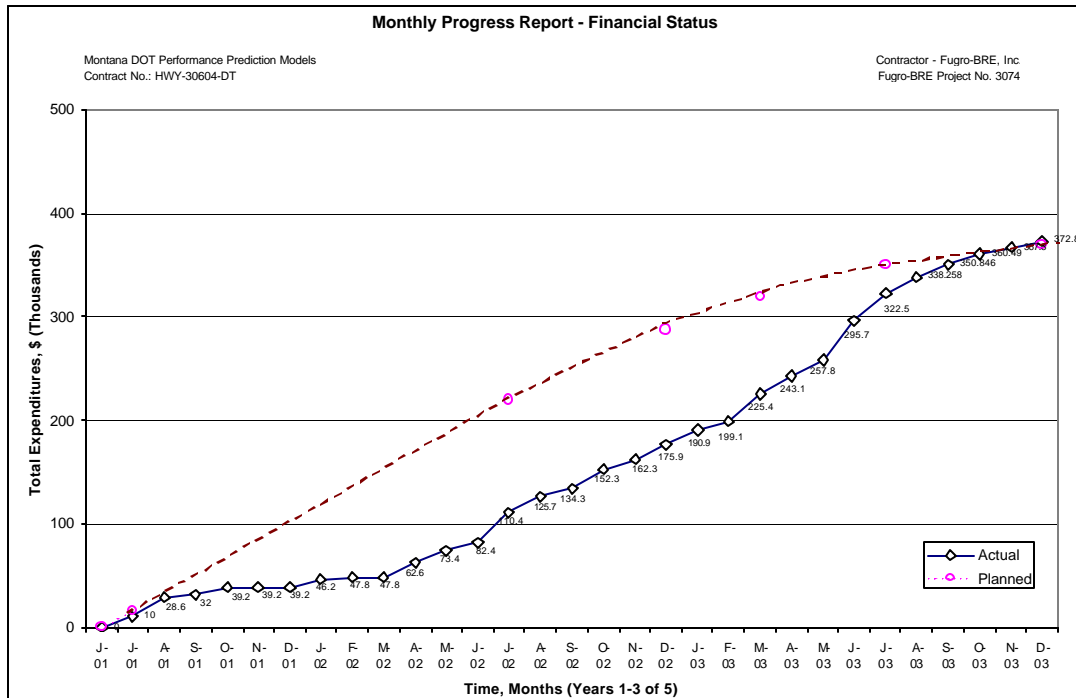
Financial Summary I
Estimated Expenses for Reporting Period: Fugro-BRE

Cost Element	Last Month's Cumulative Project Costs, \$	Current Month's Expenditures, \$	Cumulative Project Costs, \$
Direct Labor	83,284	3,675	86,960
Overhead	119,097	5,256	124,352
Consultants/Subcontractors	4,050	0	4,050
ERES/ARA	24,044	1,657	24,044
Parsons -Brinckerhoff	12,093	0	12,093
SME	523	0	523
Dr. Matthew Witczak	0	0	0
Dr. Mark Hallenbeck	0	0	3,129
Travel	14,607	0	14,607
Testing	71,994	0	71,994
Other Direct Costs	6,167	106	6,273
Fee	33,898	904	34,803
TOTAL	372,887	9,943	382,830

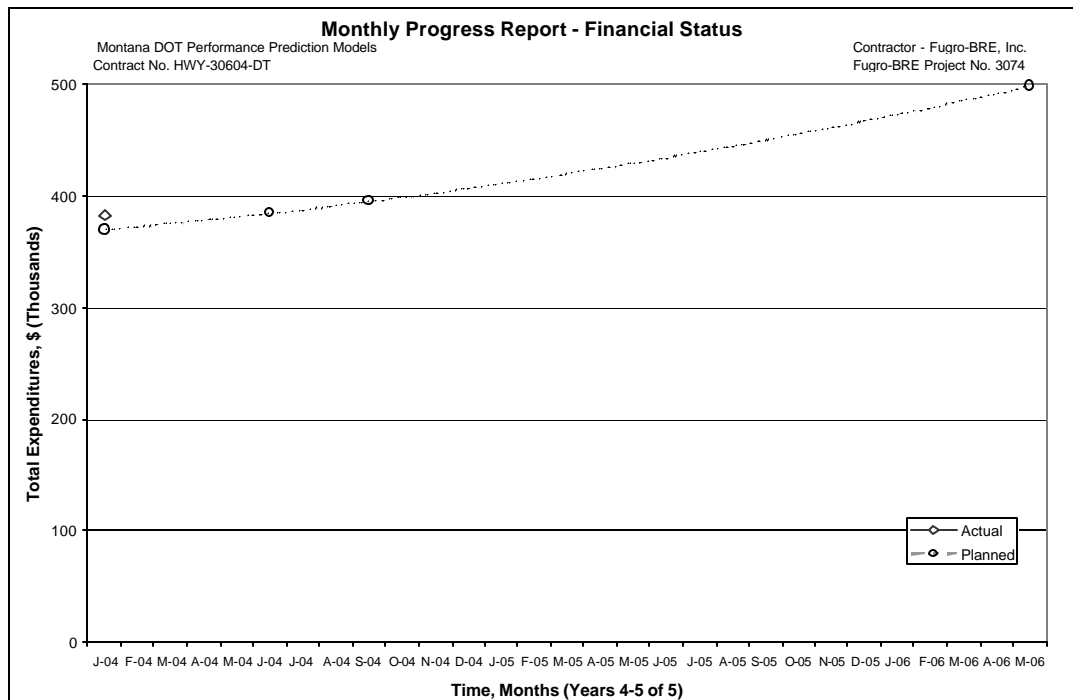
Financial Summary II
Total Expenditures by Fiscal Year: Montana and FHWA

MONTANA DOT FISCAL YEAR			FHWA FISCAL YEAR		
Fiscal Year	Cumulative Allocated Funds, \$	Cumulative Expenditures, \$	Fiscal Year	Cumulative Allocated Funds, \$	Cumulative Expenditures, \$
6/1/2000-6/30/ 2001	15,000	*0	6/1/2000-9/30/ 2001	65,000	31,996
7/1/2001-6/30/ 2002	218,969	82,420	10/1/2001-9/30/ 2002	258,969	102,303
7/1/2002-6/30/ 2003	348,969	213,291	10/1/2002-9/30/ 2003	358,969	216,187
7/1/2003-6/30/ 2004	388,969	87,087	10/1/2003-9/30/ 2004	398,969	248,429
7/1/2004-6/30/ 2005	428,969	---	10/1/2004-9/30/ 2005	438,969	---
7/1/2005-6/30/ 2006	498,969	---	10/1/2005-9/30/ 2006	498,969	---
TOTAL	498,969	382,828	TOTAL	498,969	382,830

*June 2001 expenditures were combined with July 2001 expenditures.



Financial Summary III-A: Total Expenditures By Month June 2000 – Dec 2003



Financial Summary III-B: Total Expenditures By Month Jan 2004 – May 2006